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Anatomy Of Phrynosoma
The Respiratory System

ANATOMY OF PHRYNOSOMA; THE RESPIRATORY SYSTEM

BY

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY LILLIAN DORA DOLE

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ANATOMY OF PHRYNOSOMA;

THE RESPIRATORY SYSTEM.

1. Method of Investigation .

This paper gives an account of the results obtained from the study of the respiratory system of Phrynosoma cornutum.

The investigation was carried on by means of gross dissection, microscopic sections, and wax reconstruction by the Born method. In order to obtain clear ideas of the way in which the lungs are subdivided, they were injected with water and corn starch which settled upon the partitions between the chambers, making them visible from the exterior, and permitting the correlation of the internal structure with the external form of the lung in its normal position before it was disturbed by dissection.

The respiratory system of the lizards consists of three distinct parts: larynx, trachea, and paired lungs.

II. The Larynx.

The glottis, or opening from the pharynx into the larynx, is located at the base of the tongue, as noted by all students since Stannius, and defines the posterior limit of the protrusible portion of that organ. The narrow slit-like opening of the glottis is supported by nearly parallel vertical skeletal processes, the anterior ends of the arytenoid cartileges of the larynx. Immediately in front of the opening and below it is an epithelial fold with a cartilaginous basis formed by an anterior prolongation of the cricoid cartilege of the larynx.

This fold, which is found in other reptiles, has some-

times been supposed to represent the ancestral condition of an epiglottis; however, Göppert, in discussing a similar structure in other repitles, points out that it differs in origin from the Processus epiglotticus of mammals (which arises from a distinct visceral arch) and should not be confused with it.

The furthest posterior limit of the rima glottidis is immediately behind the hook-like process of the arytenoids to be described later.

The skeletal framework of the larynx is composed of three cartileges, an unpaired cricoid and a pair of arytenoids. The cricoid consists of a depressed cylinder which surrounds the air passage. Posteriorly this cylinder is obliquely truncate, the ventral margin being somewhat more anterior than the dorsal. The anterior border is very oblique, and a little below the middle line (as viewed from the side) it extends forward as a slender process - the processus anterior inferior laryngis of Göppert. This process is considerably curved. At first it bends dorsally to pass inside the sphincter muscle which will be described in this paper; next it curves slightly downwards, and at about the level of the posterior border of the glottis it curves upwards to form the broad plate which supports the epiglottis-like fold referred to above.

In the mid-dorsal line the anterior border of the cricoid forms a short and broad processus anterior superior laryngis which is embraced between the posterior angles of the arytenoids.

A little behind the middle, the dorsal wall of the cri-

coid is perforated by a rhomboid opening (filled with connective tissue), while on the ventral surface there is a similar but much larger interruption of the cartilege which takes the shape of a letter U, the horns being directed anteriorly. The anterior ends of these horns reach forward to about the level of the superior laryngeal process. Behind the base of the U, the ventral cartilege wall of the cricoid forms but a narrow band, its width being scarcely an eighth of the length of the whole cricoid.

In Sceleporus, the general shape of the laryngeal framework is similar to that of Phrynosoma, aside from the fact, that, in spite of the relatively longer body, the laryngeal cartileges are much shorter in proportion. In Sceleporus, again, there are two ventral gaps in the cartilege, the anterior being narrower and much less U-shaped, while the posterior gap, which is considerably oblique, is but a narrow slit.

Gaps, similar in position, but differing in shape, have been figured and described by Göppert in several orders of reptiles, and are mentioned by Stannius and other authors. The appearance of the posterior part of the cricoid of Phrynosoma, as well as of Sceleporus and Cyclodus, is strongly suggestive of the view that the cricoid has been extended backwards by the inclusion of tracheal rings in its substance.

As in all Tetrapoda, the arytenoids are discrete cartileges, connected to the cricoid by fibrous tissue only. In position they are dorsal to the processus anterior inferior of the cricoid, extending forward nearly to the top of the later, and backward to the level of the processus anterior superior. Each

arytenoid is irregular in shape. In front, each is nearly flat in the vertical plane, so that the anterior end of the air passage has a vertically flattened lumen.

The anterior end of each arytenoid is expanded, especially on the dorsal side, the expansion passing in front with a regular curve into the anterior margin, while posteriorly it forms a strong hook-like process which overhangs the anterior border of the sphincter muscle. At about the middle of its length, each arytenoid suddenly widens laterally -- its dorsal margin continuing straight -- so that its posterio-inferior margin overlaps the anterior margin of the cricoid at its wider part between the two laryngeal processes, and its extreme posterior end lies entirely upon the dorsal surface of the cricoid.

Figures 1 and 2 show the dorsal and lateral aspect of the cartilaginous framework of the larynx of Phrynosoma as reconstructed in wax.

Schmidt gives a series of diagrams showing cross-sections of the larynx of Stellio vulgaris at different levels, in which the arytenoids and cricoid have the same relative position as in Phrynosoma.

The glottis is opened and closed by two sets of muscles: a sphincter laryngis, which passes around the larynx and constricts it, and a pair of longitudinal muscles which act as dilators. The sphincter extends anterio-posteriorly from the hook-like projection of the arytenoids to the level of the processus anterior superior laryngis. It is thickest in its anterior region, becoming thinner posteriorly. By the way in

which it is attached to the cartileges it is divided into two similar half-rings. It is attached ventrally by tendons to the entoglossal process of the hyoid, and dorsally to a strip of connective tissue which is a forward extension of the anterior superior process and lies between the dorsal edges of the arytenoids. The function of the sphincter is, by its contraction, to narrow the lumen between the arytenoids and at the same time to close the glottis.

The dilators are longitudinal muscles which extend along the sides of the larynx from the flattened sides of the anterior ends of the arytenoids to the unbroken ring beyond the fenestra in the posterior region of the cricoid. They pass over the sphincter, completely covering it on the lateral walls of the larynx. There function is to draw the tips of the arytenoids away from each other, thus opening the glottis. Figure 3 shows their arrangement.

The laryngeal muscles of Sceleporus are similar in position to those of Phrynosoma. Wiedersheim figures similar muscles in Phyllodactylus europaeus, and Göppert in Hatteria, while Gegenbaur's general description of the musculature of reptiles agrees with this arrangement.

As in the case of most reptiles, vocal cords are lacking in Phrynosoma. Stannius notes the absence of organs for the formation of voice in most Saurians except in the family of Ascalobota and in the group of Chamaeleonidea, where vocal cords are present as broad membranous folds in the region of the base of the arytenoid cartileges, stretching from the ventral to the dorsal wall of the larynx.

The hyoid cartileges lie below the larynx. The cricoid and anterior part of the trachea rest upon the broad concave plate of the hyoid, the copula, from which the os entoglossum extends forward furnishing attachment to the sphincter muscle, and the visceral arches extend backward on either side of the trachea just below it. The position of the hyoid cartileges is shown in Figure 3.

III. The Trachea.

The trachea is composed of completely closed cartilaginous rings which, for the most part, are entirely separated from each other, being held together by connective tissue only. However, in three or four of the more anterior rings, the cartilege of one ring is continuous with that of the next at some point on the ventral side, although the margins of these cartileges are completely separated for the greater part of their circumference.

The trachea extends backward from the larynx in a straight line, dividing at a point dorsal to the heart into two bronchi which almost immediately pass into the lungs. As the bronchial tubes continue a short distance further, the cartilege rings become thinner and less marked until the ring structure is lost and the bronchi become perforated by openings into tiny air pockets which are largest and deepest along the median side. These openings are shown in Figures 4, 5, and 6. Milani, in describing Phrynosoma, gives a diagram indicating these outpocketings from the bronchi.

IV. The Lungs.

The lungs are enveloped by membranous folds extending from the dorsal mesentery. These membranes are attached to the right

lung along its medio-dorsal side throughout its entire length, but the left, while similarly related in front, is free at the posterior end. The right lung is further held in position by a strip of mesohepar ventral to it which extends from the right lobe of the liver around the lung to a point in the back, but it is not attached to the lung.

The lungs are of considerable size, filling the dorsal part of the coelomic cavity for about four-fifths of its length. The right lung is larger than the left. At their anterior end, where the coelom narrows at the shoulder girdle, the lungs are compressed laterally. A little further back, where the shape of the body permits it, the compressed form gives way to a depressed condition which prevails throughout the greater extent of the lungs.

The compressed anterior end is divided internally by septa into three cavities which are arranged about the bronchus on its dorsal, lateral, and ventral sides, as indicated in Figure 5. These sacs open posteriorly into the main cavity of the lung at the level of the end of the bronchus.

The remainder of the lung is a large atrium partially divided into chambers by triangular epithelial septa which arise in the lateral angle of the lung and extend in an anteriomesal direction in line with the end of the bronchus.

Milani describes and figures three such septa. The writer finds that the number and extent of the septa varies, which is in accordance with the statement in Wiedersheim's Anatomy, apparently attributed to Miss Moser (though I did not find it explicitly

so stated in her article) that the interior of the lung cavities presents the greatest variation, not only within a genus, but also between individuals.

In the majority of lungs examined there were found two principal septa of nearly the same size, the smaller being in the posterior fourth of the lung and the larger about half way between the end of the bronchus and the posterior end of the lung. Each forms the mesal side of a pocket, the larger and more anterior of which extends about a third the way across the atrium from the lateral angle of the lung. The suggestion of a third septum is sometimes present as a small epithelial fold forming a tiny pocket or niche on the wall between the bases of the two septa.

In the lateral angle of the atrium, anterior to the larger septum, there are three or four small pockets, called niches by Milani, formed by folds of the lung lining. In some lungs, the most posterior of these niches may be larger than the others, due to a fold larger than usual which approaches the smaller septum in size. This condition is particularly likely to be found in the left lung, but is quite as frequently absent. Milani's sketch is identical with the interior of only one lung--a left one--examined by the writer, disagreeing with others examined in that the septum shown in the sketch just anterior to the large septum is in most cases a small fold shutting off a niche or small pocket similar to others anterior to it. Figure 6 shows the lungs of an individual in which there are two septa in the right lung and three in the left.

Tiny pockets are formed by folds of epithelium which ex-

tend across the angle between each septum and the adjacent lung walls.

In the anterior end of the main cavity of the lungs, membranous folds extend across the medial angle of the atrium, forming a series of tiny pockets smaller and more numerous than those in the lateral angle of the lung, as described above.

The interior of the entire lung, and the surfaces of the septa and of the larger folds enclosing pockets, are covered by a network of blood vessels which lie along the edge of epithelial folds standing out from the walls. These folds divide the surface into a series of shallow evaginations, the alveoli of histological text-books, the air cells of Miller and older writers. The alveoli upon the walls of the lung are arranged in small groups, separated by slightly higher partitions of epithelium through which blood vessels pass. These groups of alveoli are apparently to be homoligised with the infundibula of the mammalian lung; they are the air sacs of Miller, a term liable to lead to confusion as these structures are in no way homologous with the air sacs of the bird or the corresponding diverticula of the lungs of Chamaeleo and other lacertilians. In the posterior part of the lung, the partitions between evaginations are lower and the spaces enclosed broader than in the anterior end, making the infundibula and alveoli shallower and larger in the former region. The result of alveolar arrangement is the increase of respiratory surface.

Figures 4 and 5 show infundibula and alveoli in cross-section, while Figure 6 shows them upon the interior surface of the lung.

In closing, I wish to acknowledge my indebtedness to Professor J. S. Kingsley, under whom this work was done, for his valuable suggestions and many favors.

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DESCRIPTION OF PLATES.

Figure 1. Dorsal aspect of the cartilaginous framework of the larynx.

Figure 2. Lateral aspect of the cartilaginous framework of the larynx.

Figure 3. Dorsal aspect of the larynx in position upon the hyoid.

Figure 4. Diagram of horizontal section of lung showing alveolar arrangement.

Figure 5. Diagram of cross-section through the anterior region of the lung, showing chambers grouped about the bronchus.

Figure 6. Ventral aspect of respiratory system, showing interior of right lung.

REFERENCE LETTERS.

a - atrium of lung.
ac - anterior chamber of lung.
ar - arytenoid cartilege of the larynx.
br - bronchus
c - copula of hyoid cartilege
cr - cricoid cartilege of larynx.
d - dilator muscle of larynx.
ep - entoglossal process of the hyoid.
g - glottis
in - infundibulum, lined with alveoli.

lar - larynx
p - pocket
pi - processus anterior inferior laryngis.
ps - processus anterior superior laryngis.
s - septum
sp - sphincter muscle of larynx.
t - trachea.
va - visceral arches of hyoid.

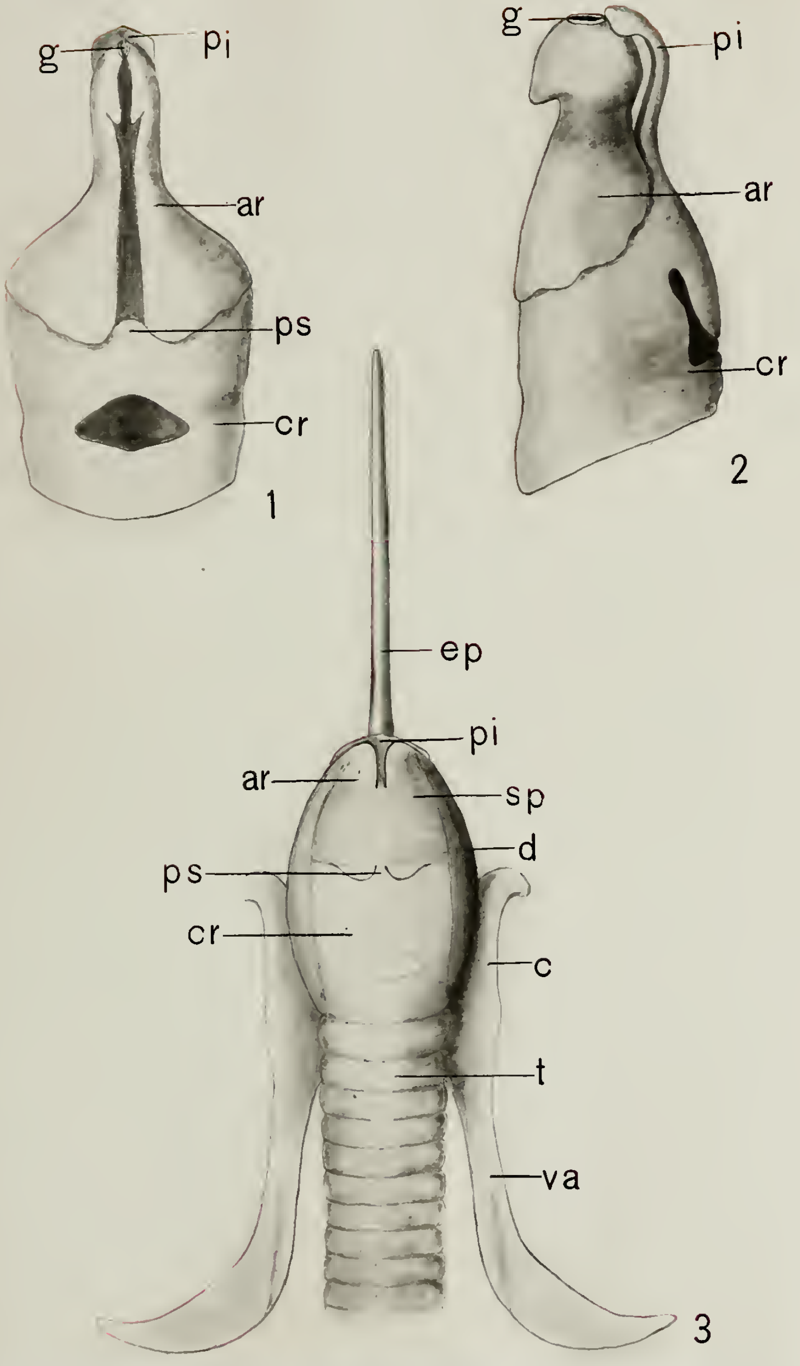
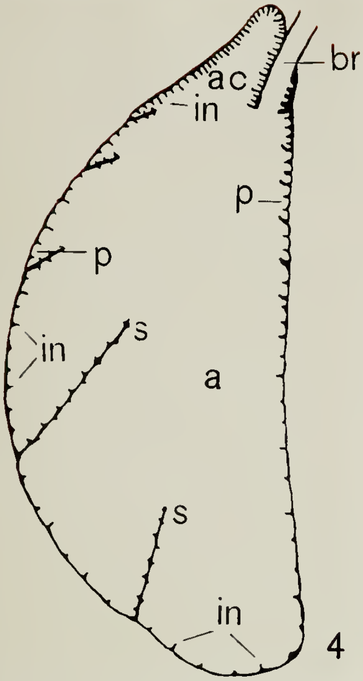


PLATE I.



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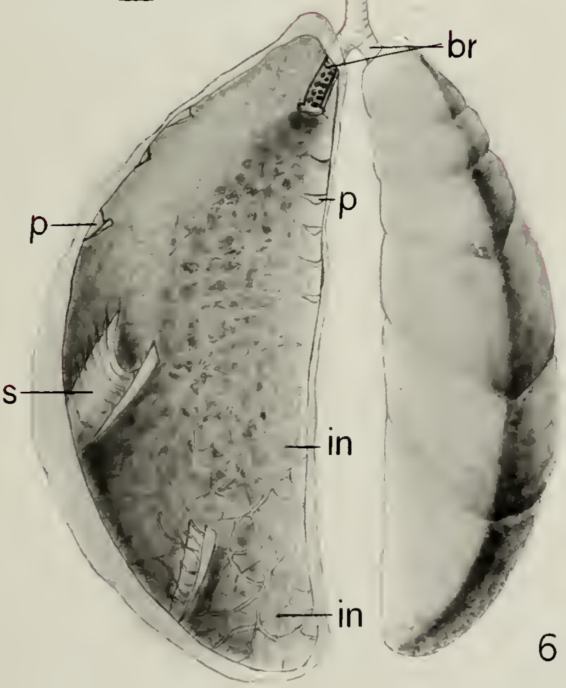

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PLATE II.